Substitute Specification

Abstract of the Invention

This invention relates to a four-stroke reciprocating piston engine with spark ignition.

On this type of engine, air rotarily enters the cylinder via an inlet valve arranged coaxially to the cylinder longitudinal axis. Rotation of the air is effected by means of guide vanes arranged in the inlet port. During the compression stroke, gaseous fuel is blown into the helically rotating air by means of a nozzle arranged remotely of the inlet valve and in the compression space and in the area of the cylinder longitudinal axis. Fuel is blown in such that an air-fuel mixture is formed only in the inner area of the cylinder and in the compression space.

As gas outlet device, a ring valve is used which does not influence the quality of the exhaust gas.

Background of the Invention

Patent Specification US 4.815.422 describes a stratified charge engine in whose cylinder and compression space a rotating, combustible and air-enclosed mixture zone of sharp contour is generated. This engine has very high efficiency and very low pollution.

As exhaust gas outlet device, a sleeve valve is used. The circular slots of the sleeve valve act as oil pockets, in particular at standstill of the engine. The exhaust gas flow conveys the accumulated oil into the exhaust.

The sleeve valve according the above-mentioned Patent Specification fully or partially cancels out the advantage of a nearly complete combustion of the fuel provided by the mixture formation process.

During engine operation, the slots in the sleeve valve slide over the seals.

If the seals are positioned such that the slots of the sleeve valve do not slide over the seals, the sleeve valve is either not gas-tight or it rubs on the cylinder without lubrication.

Therefore, a device for the burning of oil is required. The very high oxygen excess in the exhaust gas allows for the use of a thermal reactor. However, a thermal reactor requires a very long warm-up phase to become effective. Since the exhaust gas temperature is very low with this process, the thermal reactor will, irrespective of the operating state, never reach the temperature necessary for the combustion of the oil. Similar difficulties are encountered with a catalyst.

In order to effect post-combustion of the oil, the thermal reactor or catalyst or the exhaust gas must be heated up electrically of by means of fuel – which is energy-expensive. Also, the operating time of catalysts is very limited.

The design described in Colgate Application GB 2 150 636 A also fails to meet the desired objects.

In the Colgate Application, the air entering the cylinder meets the highly turbulent residual gas.

Turbulence is caused by the exhaust valve arranged remotely of the cylinder longitudinal axis.

Due to the turbulence of the residual gas and the strong deflection of the air entering the cylinder towards the piston, the flow is turbulent and significantly deviates from a block flow.

The shape and the direction of the fuel jet similarly lead to a very uneven distribution of the fuel in the air. In the center and in the area of the cylinder head, the mixture is overrich. In the piston area, the rotating air centrifuges the fuel droplets against the cylinder wall. The mixture is too lean. Mixture gets into the gap between the cylinder and the piston (blow up). If gas is blown into the cylinder, the engine operates like a conventional engine, without the intended improvements. An essentially homogenous mixture is formed which completely fills the cylinder space.

The means described in the Colgate Application do not provide for the formation of a rotating and air-enveloped mixture zone of exact shape.

With piston engines, fuel efficiency must be increased on the one hand and pollutant formation during combustion minimized on the other hand.

The present invention, in a broad aspect, provides a combination of a stratified charge engine with an outlet device to achieve high fuel efficiency and essentially pollutant-free exhaust gas.

Brief Summary of the Invention

This invention relates to a four-stroke reciprocating piston engine with spark ignition, as described in Patent Specification US 4.815.422.

A four-stroke piston engine in which air is drawn into a cylinder while rotary motion about the cylinder axis is imparted to the air. Fuel may be blown/injected into the air during its rotation in the cylinder, with the fuel supply being located on the axis of the cylinder and supplying at least one jet of fuel initially directed radially outwards and substantially transversely to the axis of rotation by means

of a fuel delivery device, fuel-conducting means and at least one nozzle connected to said fuel-conducting means, this jet of fuel, together with the rotating air, forming at least one helical flow of mixture within the cylinder preferably during the compression stroke which is transformed into a coherent mixture zone enclosed by a ring of air upon completion of compression. The piston can have a recess to form, when the piston approaches the top dead center, an enriched zone in the lower region of the compression space which is ignitable by electrodes arranged in said lower region of the compression space. The stratified charge in the cylinder of the stratified-charge engine comprises a mixture zone of comparatively small volume which can have different fuel concentrations plus a thermally insulating zone of air.

In order to create in the piston-swept and compression spaces an essentially rotationally symmetric zone of desired basic mixture whose fuel content is essentially constant also over the cylinder longitudinal axis and wherein the diameter of the zone is smaller than the cylinder diameter, fuel delivery curves of the fuel pump are required which correspond to the characteristic fuel demand curves of the engine. The shapes of the characteristic fuel demand curves are defined, in particular, by the parameters relating to the airflow, which vary during mixture formation, and by the load.

If the parameters relating to the fuel are matched to the parameters relating to the airflow in such a manner that the differential pressures between the fuel delivery device and the cylinder change during a single mixture forming process, the desired result with respect to volume and air ratio of the air-enclosed mixture zone can be achieved.

Various designs of gas outlet devices are known. The simply designed disk valve has gained general acceptance over the sleeve valve and the plain slide valve. However, disk valves are not suitable for engines in which a turbulence-free flow is requisite for the formation of an air-enclosed mixture zone of sharp contour.

For this type of engine, only a ring valve is suitable since it does not disturb the rotationally symmetric design of the compression and cylinder space.

The ring valve is arranged co-axially with the cylinder longitudinal axis, with the cylinder head and/or the cylinder acting as guide.

Location of the ring valve is also effected in that it is rotatable about the cylinder longitudinal axis and shiftable in the direction of the cylinder longitudinal axis.

A great variety of design options for the ring valve exist, depending on the type of ring valve actuation. Common to all designs is the annular portion in the area of the compression space.

The circular face of the ring valve together with a ring valve support abutting a tubular cylinder insert form the sealing faces. The sealing faces on the ring valve and the sealing faces of the firmly installed ring valve support can be concave/convex as well as Vee-/wedge-shaped.

The ring valve and the ring valve support seal, with their sealing faces, the compression and cylinder space against the outlet port essentially during three strokes, with the sealing faces having a certain distance to that part of the cylinder head which partially forms the compression space.

In the gas exhaust stroke, the ring valve is lifted off the ring valve support by means of suitable devices, enabling the exhaust gas to travel to the outlet port which partly encloses the cylinder. It may be suitable to provide two outlet ports offset by 180 degrees.

The opening and closing movement of the ring valve can, in dependence of certain parameters, be actuated by mechanical devices.

Two mechanical/hydraulic devices are detailed in the following section.

The end of the ring valve opposite of the sealing faces can be designed as ring piston. Two hydraulic pumps, each essentially consisting of cylinder, piston and a rotary cam acting on the piston, reciprocally apply oil to the ring piston.

The ring valve can also be actuated by two 180°-offset hydraulic devices in connection with valve springs, with the two hydraulic devices being interconnected by a line for pressure compensation.

All valve actuation devices prevent the ring valve from tipping, canting or sticking.

The gap between cylinder and ring valve and between ring valve and cylinder head is sealed in the area of the compression space by means of two annular seals.

Brief Description of the Drawings

Fig. 1
Position of the ring valve in the engine

Fig. 2
Section through the ring valve

Fig. 3
Illustration of the sealing areas

Fig. 4
Section through the cylinder and the cylinder head

Detailed Description of the Engine

Fig. 1

1	Cylinder head
2	Air inlet port/channel
3	Inlet valve
4	Air vanes
5	Nozzle and electrode carrier
6	Fuel nozzle
7	Ignition device
8	Cylinder chamber
9	Cylinder
10	Exhaust outlet port/channel
11	Cylinder insert
12	Ring valve support
13	Ring valve
14	Ring valve piston

Fig. 2

1	Cylinder head
13	Ring valve
14	Ring valve piston
15	Seal
16	Seal
17	Raising oil channel
18	Raising oil ring channel
19	Closing oil channel
20	Closing oil ring channel
9	Cylinder
10	Exhaust outlet port/channel
12	Ring valve support
8	Cylinder chamber

Fig. 3

12	Ring valve support
13	Ring valve
21	Vee-shaped sealing area on ring valve
22	Vee-shaped sealing area on ring valve support
23	Cooling channel in ring valve
24	Cooling channel in ring valve support

Fig. 4

30	Piston
31	Helically rotating air
32	Gaseous fuel jet

Operation

The unrestricted inflow of air into the cylinder passes around the inlet valve, which is arranged co-axially to the cylinder longitudinal axis, and the hot residual gas rotating beneath the inlet valve. In the region of the cylinder, the boundary layer is smoothed by the ring valve slightly lifted at the beginning of the intake stroke. Valve overlap causes short-term boundary layer suction. The helically flowing air rotates essentially turbulence-free and free of any essential singularities.

During the compression stroke, the air flows helically rotating towards the cylinder head. By means of a nozzle arranged remotely of the inlet valve in the area of the cylinder longitudinal axis and in the compression space, gaseous fuel is blown into the helically rotating air such that an air-enclosed, rotating mixture zone is formed. In addition, an ignition mixture cloud is formed in the area of the cylinder longitudinal axis which is ignited by an ignition spark.

The mixture formation and combustion process provides for high air excess in the mixture. The relatively small quench zones and the fuel-free air between piston and cylinder (no blow-by) essentially result in complete combustion of the fuel. The marginal pollutant quantity (HC) resulting from combustion can, if necessary, be oxidized simply and inexpensively.

The ring valve described does not affect the quality of the exhaust gas. Oil is prevented from getting into the exhaust gas.

The combination of the mixture formation and combustion process with the ring valve is economical and a decisive step toward a zero-emission engine.

Combustion of the air-enclosed, rotating mixture zone of sharp contour reduces heat losses and, thus, provides for better fuel economy.

Gaseous fuels are preferably used. Liquid fuels must be gasified before they are blown into the cylinder.